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Growth and Yield of Maize as Influenced by Drip Fertigation

M. K. Shruthi and T. Sheshadri
Department of Agronomy, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail: shruthimangala21@gmail.com

Abstract

A field experiment was conducted at Zonal Agricultural Research Station, V.C. Farm, Mandya, University of Agricultural Sciences, Bengaluru during *Kharif,* 2015 to study the effect of drip fertigation on growth and yield of drip irrigated maize (*Zea mays* L.). The results revealed that application of 125 per cent of recommended nitrogen and potassium through drip fertigation with four or eight days interval with fertigation duration of 25 per cent from sowing to 30 DAS + 50 per cent at 31 to 50 DAS + 25 per cent at 51 to 80 DAS resulted in higher kernel yield (8869 kg ha^{-1}) and stover yield (10715 kg ha^{-1}) of maize. Whereas, drip fertigation of 75 per cent of recommended nitrogen and potassium with the same fertigation duration was found on par with 100 per cent recommended NPK application under surface irrigation method.

Keywords: Drip irrigation, fertigation schedule, leaf area, maize yield, harvest index

Maize (*Zea mays* L), globally an important cereal crop next to wheat and rice also known as Queen of Cereals because of its highest genetic yield potential among cereals. It is the most versatile emerging crop having wider adaptability under varied agro-climatic conditions. Maize is being consumed as food, fodder and also has industrial uses. In India, about 25 per cent of the maize produced is used for human consumption, 49 per cent in poultry and 12 per cent as cattle feed and 12 per cent in food processing industries mainly as starch and one per cent each in brewery and seed (Jat *et al.,* 2009). In India, it is cultivated in an area of 9.4 million hectare with production of 22.27 million tonnes. However, the productivity is 2.5 t ha^{-1} which is much lower than the global average. Karnataka being major maize producing state alone contributes 16.5 per cent of the total maize production with an area of 1.3 million hectare with production of 4.0 million tonnes and productivity of 2.88 t ha^{-1} (Anon., 2016). Although, the state productivity is greater than the national average, but it is still lower than global average. Its special features like higher dry matter production, ability to suppress weeds and high adaptability to both rain fed and irrigated situations have favoured expansion of its area.

Globally agriculture uses approximately 70 per cent of total water withdrawals. However, the majority of large-scale irrigation systems are performing well below their potential. The overall efficiency of the flood irrigation system ranges between 25 to 40 per cent. Adoption of micro irrigation may help in saving significant amount of water and increase the quality and quantity of the produce emphasizing the need for water conservation and improvement in water-use efficiency to achieve 'more crop per drop'. Many scientists have listed number of potential advantages for micro irrigation such as increased beneficial use of water, enhanced plant growth and yield, reduced salinity hazard, enhanced efficiency of fertilizer and other chemicals, limited weed growth, decreased energy requirements and improved cultural practices. Studies revealed that the fertigation through drip irrigation in maize improves the nutrient availability to the crop through nutrient distribution within the crop root zone which improves better crop uptake and reduces the loss of nutrients (Anitta, 2013). Therefore, to standardize the fertigation technique to the drip irrigated maize to achieve higher yield with reduced water and nutrient loss present study was undertaken.

Material and Methods

A field experiment was conducted during *Kharif* - 2015 at Zonal Agricultural Research Station, V.C.

Farm, Mandya, Southern Dry Zone (Zone-6) of Karnataka. The experimental site is located between 12º 51' N Latitude and 77º 35' E Longitude at an altitude of 930 m above Mean Sea Level (MSL). The soil is sandy loam in texture with low organic carbon content and soil pH of 6.9 and EC of 0.32 dSm^{-1}. Initial nitrogen, phosphorus and potassium status of the soil were 248.4, 26.50 and 189.3 kg ha^{-1}, respectively. The field experiment was laid out in a Randomized Complete Block Design with three replications using factorial concept involving different fertigation intervals of once in 4 days (I_1) and 8 days (I_2) with fertigation duration as D_1: 25 per cent RDF (from sowing to 30 DAS) + 50 per cent RDF (31 to 50 DAS) + 25 per cent RDF (51 to 80 DAS) and D_2: 50 per cent RDF (from sowing to 30 DAS) + 25 per cent RDF (31 to 50 DAS) + 25 per cent RDF (51 to 80 DAS) with varied levels of fertilizers *i.e*., 75 per cent (F_1), 100 per cent (F_2) and 125 per cent (F_3) of recommended NPK. Phosphorus was applied as basal dose through soil applications. Growth and yield observations of the crop were recorded at 30, 60 and 90 days after sowing and at harvest and subjected to statistical analysis. The drip line was passed in between paired row. This system included pump, filter units, fertigation tank, ventury, main line and sub line with control valves for each plots to regulate the fertigation frequency and duration. Calculated quantity of phosphorus was applied to all the treatments through single super phosphate by soil application basally, whereas, nitrogen and potassium were supplied through drip fertigation starting from 6^{th} day after sowing as per the treatments using water soluble urea and muriate of potash, respectively. Drip irrigation was given once in two days and fertigation was as per the treatments.

Results and Discussion

The growth parameters of maize were significantly influenced by varied fertilizer levels and fertigation duration. Among different fertigation durations studied the treatment with split application in 25 per cent RDF (from sowing to 30 DAS) + 50 per cent RDF (31 to 50 DAS) + 25 per cent RDF (51 to 80 DAS) recorded higher plant height of 184.8 cm with 12.69 leaves $plant^{-1}$and leaf area of 6976 cm^2 $plant^{-1}$, respectively when compared to 50 per cent RDF (from sowing to 30 DAS) + 25 per cent RDF (31 to 50 DAS) + 25 per cent RDF (51 to 80 DAS) which recorded plant height of 177.6 cm with 12.05 leaves $plant^{-1}$ and leaf area of 6312 cm^2 $plant^{-1}$ in the study. Further, different fertilizer levels have also shown significant difference where the plant height, number of leaves and leaf area were found significantly higher with 125 per cent of recommended NPK application (187.4 cm, 12.89, 7276 cm^2 $plant^{-1}$, respectively) followed by 100 per cent recommended NPK (182.9 cm,12.15, 6380 cm^2 $plant^{-1}$, respectively). The lower plant height (173.3 cm), number of leaves (12.07) and leaf area (6275 cm^2 $plant^{-1}$) were recorded with 75 per cent recommended NPK application. However, fertigation interval did not show significant difference on growth parameters (Table I).

Among the interactions, higher plant height (195.28 cm), number of leaves (13.53) and leaf area (7495 cm^2 $plant^{-1}$) were found with the treatment comprising 125 per cent NPK application as fertigation in split doses as 25 per cent RDF (from sowing to 30 DAS) + 50 per cent RDF (31 to 50 DAS) + 25 per cent RDF (51 to 80 DAS) followed by 125 per cent NPK application as 50 per cent RDF (from sowing to 30 DAS) + 25 per cent RDF (31 to 50 DAS) + 25 per cent RDF (51 to 80 DAS) recorded irrespective of fertigation frequency (Table I). Whereas lower growth attributes were recorded with the surface irrigation method (control- soil application of nutrients as 50 per cent recommended N and 100 per cent PK basal and one top dress with 50 per cent N at 40 DAS) which was on par with 75 per cent recommended NPK application under drip fertigation (Table I). The fertigation interval did not influence the growth parameters of crop significantly. Fertigation once in four days interval established comparatively good response under drip irrigation cultivation of maize with other factors under investigation. Since initial growth could be supported by soil nutrient status split application through drip fertigation could ensure the nutrient availability to the crop growth and development during later stages. The higher nutrient availability during grand growth period further attributed to higher photosynthates production. The results are in conformity with the finding of Amrutha *et al*. (2016) and Kumar *et al*. (2014).

TABLE I

Growth parameters of maize as influenced by fertigation interval, duration and fertilizer levels

Intervals	Plant height (cm)	No. of Leaves	Leaf area (cm^2 $plant^{-1}$)
I_1	181.8	12.41	6748
I_2	180.6	12.33	6540
SEm±	1.53	0.14	123
CD (p=0.05)	NS	NS	NS
Durations			
D_1	184.8	12.69	6976
D_2	177.6	12.05	6312
SEm±	1.53	0.14	123
CD (p=0.05)	4.46	0.40	358
Fertilizer Levels			
F_1	173.3	12.07	6275
F_2	182.9	12.15	6380
F_3	187.4	12.89	7276
SEm±	1.87	0.17	150
CD (p=0.05)	5.47	0.49	439
Interaction (IXDXF)			
$I_1D_1F_1$	172.7	12.33	6999
$I_1D_1F_2$	182.9	12.07	6209
$I_1D_1F_3$	195.3	13.53	7495
$I_1D_2F_1$	171.2	12.07	6076
$I_1D_2F_2$	188.3	11.93	6343
$I_1D_2F_3$	180.3	12.53	7364
$I_2D_1F_1$	181.0	12.13	6695
$I_2D_1F_2$	182.9	12.47	6603
$I_2D_1F_3$	194.6	13.60	7853
$I_2D_2F_1$	168.1	12.07	5332
$I_2D_2F_2$	177.6	11.80	6365
$I_2D_2F_3$	179.9	11.90	6393
CONTROL	166.1	11.60	5991
SEm±	3.75	0.34	301
CD (p=0.05)	10.87	0.98	878.92

Note: I_1: Fertigation once in 4 days,
I_2: Fertigation once in 8 days
D_1: 25 % RDF (from sowing to 30 DAS) + 50 % RDF (31 to 50 DAS) + 25 % RDF (51 to 80 DAS)
D_2: 50 % RDF (from sowing to 30 DAS) + 25 % RDF (31 to 50 DAS) + 25 % RDF (51 to 80 DAS)
F_1: 75 % of recommended dose of NPK
F_2: 100 % of recommended dose of NPK
F_3: 125 % of recommended dose of NPK
Control: Surface irrigation with soil application of recommended NPK (150:75:40 kg ha-

Simlarly the yield parameters were also higher with 125 per cent NPK application as fertigation given in split doses as 25 per cent RDF (from sowing to 30 DAS) + 50 per cent RDF (31 to 50 DAS) + 25 per cent RDF (51 to 80 DAS) recorded higher kernel yield (8869 kg ha^{-1}) and stover yield (10715 kg ha^{-1}), number of kernel rows (16.47), kernel weight per cob (141.82 g) and higher 100 kernel weight (34.83 g) compared to the control (6811, 8145 kg ha^{-1}, 14.17, 126.21 g and 30.43 g, respectively) and followed the same trend as observed in case of growth parameters (Table II). As the split application of nutrients through drip fertigation would ensure the higher nutrient availability throughout crop growth period and meets the crop needs for better photosynthates production and accumulation. Further, significant increase in growth and yield attributes contributed for higher kernel and stover yield of maize. This might be due to higher availability of nutrients to the crop according its requirement resulted in better translocation of photosynthates and reduced loss of nutrients under drip fertigation with split application according to the crop need. The results are in confirmation with Sampathkumar and Pandian (2010), Richa Khanna (2013), Reddy and Krishnamurthy (2017).

Among correlation studies, the kernel yield exhibited significant positive correlation with growth parameters like plant height (r = 0.87), number of leaves (r = 0.73) and leaf area $plant^{-1}$ (r = 0.87) and also the yield parameters such as number of kernel rows cob (r = 0.84), kernel weight cob^{-1} (r = 0.96) and 100 seed weight (r = 0.87) showed that kernel yield was determined by these parameters was observed for both growth and yield parameters with the maize yield (Table III). The results are in conformity with findings of Anusha (2015) in rice.

The results suggested that drip fertigation with an interval of four or eight days and split application ensuring maximum nutrient application at grand growth period might enhanced the availability of nutrient to the crop with improved growth and yield further resulted in achieving the maximum yield of maize under drip irrigated condition.

TABLE II

Yield and yield parameters of maize as influenced by fertigation interval, duration and fertilizer levels

Intervals	Number of kernel rows cob^{-1}	Kernel weight cob^{-1} (g)	100 Kernel weight (g)	Kernel yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index
I_1	15.06	144.81	32.66	7926	9817	0.45
I_2	14.69	142.00	32.12	7881	9506	0.45
SEm±	0.13	1.23	0.21	84	145	-
CD (p=0.05)	NS	NS	NS	NS	NS	-
DURATIONS						
D_1	15.22	147.21	32.73	8104	9923	0.45
D_2	14.52	139.60	32.04	7704	9400	0.45
SEm±	0.13	1.23	0.21	84	145	-
CD (p=0.05)	0.37	3.58	0.60	245	424	-
FERTILIZE LEVELS						
F_1	14.27	130.80	31.75	7295	8668	0.46
F_2	14.78	142.89	31.93	7827	9760	0.45
F_3	15.57	156.53	33.49	8589	10557	0.45
SEm±	0.16	1.50	0.25	102	177	-
CD (p=0.05)	0.46	4.38	0.73	301	520	-
Interaction (IXDXF)						
$I_1D_1F_1$	14.40	134.57	32.23	7676	9971	0.43
$I_1D_1F_2$	14.60	141.82	31.53	7875	10184	0.44
$I_1D_1F_3$	16.47	159.63	34.83	8869	10715	0.45
$I_1D_2F_1$	13.53	117.94	32.00	6930	7849	0.47
$I_1D_2F_2$	14.47	140.31	32.23	7795	9878	0.44
$I_1D_2F_3$	14.67	157.71	33.13	8413	10305	0.45
$I_2D_1F_1$	14.67	141.03	31.83	7672	8694	0.47
$I_2D_1F_2$	15.07	147.76	31.93	7761	9579	0.45
$I_2D_1F_3$	16.13	158.48	34.03	8771	10398	0.46
$I_2D_2F_1$	14.47	129.67	30.93	6904	8157	0.46
$I_2D_2F_2$	15.00	141.67	32.00	7878	9399	0.46
$I_2D_2F_3$	15.00	150.29	31.97	8301	10810	0.43
CONTROL	14.17	126.21	30.43	6811	8145	0.46
SEm±	0.31	3.00	0.50	199	340	-
CD (p=0.05)	0.90	8.76	1.45	582	992	-

Note: I_1: Fertigation once in 4 days,
I_2: Fertigation once in 8 days
D_1: 25 % RDF (from sowing to 30 DAS) + 50 % RDF (31 to 50 DAS) + 25 % RDF (51 to 80 DAS)
D_2: 50 % RDF (from sowing to 30 DAS) + 25 % RDF (31 to 50 DAS) + 25 % RDF (51 to 80 DAS)
F_1: 75 % of recommended dose of NPK,
F_2: 100 % of recommended dose of NPK
F_3: 125 % of recommended dose of NPK

Control: Surface irrigation with soil application of recommended NPK (150:75:40 kg ha^{-1})

TABLE III

Correlation and regression equation for growth and yield components with yield as influenced by fertigation interval, duration and fertilizer levels

Parameters	Correlation coefficient (R)		Regression equation Y {Kernel yield (kg ha-1)}			R^2
	Between yield vs growth parameters					
Growth components						
Plant height at harvest	0.87	**	Y=	63.032X	- 3530.5	0.75
Number of leaves at harvest	0.73	**	Y=	791.94X	-1929.1	0.53
Leaf area at harvest	0.84	**	Y=	0.8126X	+2461.7	0.71
Between yield and yield components						
Between yield and yield components						
Number of kernel rows cob^{-1}	0.84	**	Y=	485.48X	- 7830.3	0.74
Kernel weight cob^{-1} (g)	0.96	**	Y=	49.227X	+825.34	0.90
100 kernel weight (g)	0.86	**	Y=	721.87X	- 2877.9	0.70

Note : The independent variable X refers to the parameters listed in serial number
Y is dependent variable kernel yield in kg ha^{-1}
**Correlation is significant at P = 0.01

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